

Management of the Acute Radiation Syndrome

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Classification of radiation injury on a clinical basis is useful for determining priorities of evacuation and treatment in a mass casualty situation. Victims of nuclear attack would probably also suffer traumatic and thermal injuries. Four categories of surgical injury have therefore been combined with three categories of radiation injury to yield 12 classes of patients whose disposition is described. The treatment of the acute radiation syndrome is briefly discussed and concurrent injuries from trauma and burns and their possible implications are considered.

THIS paper presents a method for the management of casualties when large numbers of persons have been exposed to ionizing gamma radiation. While it is designed for application after a nuclear attack, the principles are equally applicable following a nuclear accident involving moderate numbers of casualties. The method to be described is in accordance with the principles of mass casualty care accepted by the Emergency Health Services and is within the capabilities of the established units of that organization.

Under the conditions of nuclear attack many of the casualties will likely be suffering from injuries other than those induced by radiation alone. Accordingly the acute radiation syndrome will be discussed first as an entity and secondly in conjunction with associated injury. The hazards resulting from contamination with radioactive material in contact with the body surface are not considered in this article. Their nature and management have been discussed elsewhere.¹

CLASSIFICATION OF RADIATION CASUALTIES

The degree of injury resulting from radiation is proportional to the dosage received. As the dosage is increased, there is a change in the pattern of the syndrome characterized by a shortening of the latent period between exposure and onset of symptoms and an alteration in the dominating manifestation. The latter may be hemopoietic, gastrointestinal or neurological in nature. A classification of casualties according to dose received would be possible if this dose could be accurately estimated in a manner rela-

Il peut être utile au point de vue clinique de classer les lésions provenant de radiation, pour établir les priorités d'évacuation et de traitement dans une situation où les victimes sont très nombreuses. Les victimes d'une attaque nucléaire souffriraient aussi probablement de blessures d'origine traumatique et thermique. On a donc combiné quatre catégories de blessures chirurgicales à trois catégories de lésions consécutives à la radiation pour former 12 classes de patients dont on explique comment en disposer. L'article décrit brièvement le traitement du syndrome post-radiation et envisage le traitement des blessures concomitantes provenant de traumatisme, de brûlures et leurs conséquences possibles.

ted to the biological state of the patient. Even if personal dose meters were available, the inconsistencies resulting from the irregularity of the distribution of the dose, the possibility of some portion of the body remote from the dose meter being shielded, or the dose meter being exposed to a higher dose than the individual, would preclude their use for classification of casualties. For these reasons a clinical classification of the patient, provided it is flexible and continuous, is the most practical. Thus reclassification should occur as other aids such as hematological studies become available.

In attempting to utilize a clinical classification it is important to realize that symptomatology may be due to stresses other than the acute radiation syndrome. Thus gastrointestinal symptoms of nausea, vomiting and diarrhea may be of psychogenic origin, while shock and unconsciousness may be the result of trauma. If the symptomatology can be ascribed directly to radiation, it is possible to classify the casualty into one of the following three categories:²

Category A—Recovery is probable even without treatment. This category will include those who are asymptomatic or in whom there may be transient nausea lasting less than 24 hours. The occurrence of vomiting will classify the patient in a more serious category. These patients require no treatment but should be observed for four to six weeks. The majority will have received a total body dose of less than 200 rads.

Category B—Recovery is possible. This group will include a wide spectrum, some of whom will require the utmost in supportive therapy for recovery, while others will require little or no treatment. These patients will suffer from

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nausea and vomiting. Vomiting may be early in onset, within one or two hours; it may persist for 24 to 48 hours but then should subside and be followed by a relatively asymptomatic period of from four days to two to three weeks.

Early diarrhea of any severity should not occur; however, after a latent period of one to three weeks, diarrhea may develop in association with severe hemopoietic depression.

In some patients the total white blood count and thrombocyte counts will be depressed during the second or third week. This depression may be very severe, to levels of less than 200 cells, and still be compatible with recovery. Lymphopenia is noted in the first one to three days, but neutropenia appears later.

Patients in whom depilation occurs after the second week should be classified in this group.

The radiation dosage received by patients in this category should be less than 1000 rads, but may be as low as 150-200 rads.

Category C—Recovery is improbable in patients in whom symptoms are early in onset and progressive in nature. This group includes those whose nausea and vomiting begins within one to two hours after exposure, progresses, and is associated with explosive diarrhea of a persistent type occurring within 48 hours. Shock and prostration develop rapidly. Some patients exhibit evidence of central nervous system damage as manifested by ataxia, nystagmus, muscle tremors, unconsciousness and, rarely, convulsions.

MANAGEMENT AND TREATMENT

Using these categories, a guide to early sorting can be drawn up (Table I). In the treatment of radiation casualties where recovery is possible there is a sufficient latent period between the time of exposure and the appearance of serious effects that urgency is not a consideration. Furthermore, there is no specific treatment to prevent the effects of radiation.

Under the conditions that prevail initially, professional medical personnel may be absent. Sorting of casualties and a determination of priority on a rough basis only can be instituted. The use of antiemetics (e.g. dimenhydrinate) may prevent vomiting in some patients who would otherwise be considered as Category B patients. However, antiemetics are unlikely to be effective in patients who have received higher dosages and the response to the use of these drugs may be a help in further sorting.

Once a physician is available, more accurate classification is possible. At this stage it is unlikely that hematological studies could be per-

TABLE I.—UNWOUNDED RADIATION CASUALTIES—GUIDE FOR EARLY SORTING

| <i>Clinical findings</i> | <i>Radiation category</i> | | |
|--------------------------|----------------------------|----------------------------|-------------------------|
| | <i>A</i> | <i>B</i> | <i>C</i> |
| Nausea | Lasting less than 24 hours | Lasting up to 48 hours | Early onset |
| Vomiting | — | Lasting up to 48 hours | Early onset |
| Diarrhea | — | Late onset after five days | Onset within three days |

formed and that anything more than minimal care could be given. If the injuries are due to radiation only, then probably little or no care will be required except for the most severely injured.

Patients in Category A should be able to evacuate themselves to areas where hematological studies can be carried out. These patients may require observation for as long as three to six weeks. Patients in Category B should be removed to areas where more extensive studies and supportive care are available as soon as possible. The use of antiemetics and sedation at this stage may be helpful. Some patients may become sufficiently dehydrated to warrant the administration of parenteral fluids, but the use of prophylactic antibiotics is not indicated.

Those who are in Category C should be given sedation and some supportive care; observation may be necessary to confirm their basic classification within this category. Most of the patients will die within one to four days, and under the conditions of a nuclear attack evacuation to more adequate areas on an urgent priority is not justified.

In those areas where facilities for hematological studies are available, further classification of patients can occur. Those patients who have hemopoietic depression without severe gastrointestinal damage will not require reclassification.

The first problem is to determine as soon as possible those who will require supportive therapy for recovery. These will include patients suffering from marked lymphopenia in 24 hours, those with a total nucleated count of less than 2000 in a week, and patients with total nucleated counts below 1500 at any stage. In addition, patients exhibiting severe thrombocytopenia or even moderate depression of the platelets will require care.

The aim of management of these patients is to prevent or treat infection and hemorrhage during the period of risk in order to allow recovery of the bone marrow. In most situations this will

include isolation of the patient, barrier nursing techniques and administration of blood and platelet preparations. The use of antibiotics prophylactically is likely only to alter the intestinal flora and permit overgrowth by an untreatable organism which then invades the body. One exception to this would be situations where optimal care is available and the patient can be placed in a sterile environment (the so-called "life island"). In these circumstances an attempt is made to sterilize the skin and gastrointestinal tract by the use of oral non-absorbable antibiotics, employing a combination with varying spectra of activity on a cyclic basis.

Where there is severe hemopoietic depression, the organisms most likely to cause problems include the enteric organisms, *Pseudomonas aeruginosa* and *Candida*, which may produce a septicemia that is difficult to treat. The therapy for these patients frequently requires the use of ampicillin, the polymyxins, kanamycin and the antifungal agents nystatin and amphotericin B. In the patient without white cells bacteriostatic agents are of little help in the control of systemic infection, and bactericidal drugs should be used where possible.

In patients suffering from thrombocytopenia, platelets may be administered when bleeding occurs. Where the supplies are adequate, these may be administered prophylactically to patients whose platelet counts fall below 20,000/c.mm. In most instances these should be given as platelet-rich plasma, the red cells being utilized in patients who are anemic.

After the first few days there may be an onset of diarrhea with or without melena. This does not have the same serious prognosis as does diarrhea earlier in the course of the disease. It will require sedation and careful attention to fluid and electrolyte imbalance, but with adequate supportive care recovery will be possible in some patients.

Where the conditions for treatment are ideal there will be some patients in whom bone marrow transplantation should be considered as a treatment for the severe depression of their hemopoietic system. While potentially life-saving in some patients who have received high dosages of radiation, this procedure may actually interfere with recovery in others whose radiation dosages have been in the lower range. The decision for bone marrow transplantation should be made only where reasonably accurate estimates of dosage are possible.

It may be necessary to sustain the patient for as long as eight weeks, by which time recovery should be established. The initial stages of re-

covery may be heralded by a rise in reticulocytes or platelets before there is any apparent change in white blood counts.

COMBINED INJURY EFFECTS

Under the conditions of nuclear attack, casualties will likely be suffering from traumatic and thermal injuries in addition to the effects of radiation. The assignment of priorities for evacuation and/or treatment will therefore be based on an assessment of each type of injury. In general one may state that the disposal of the patient will be determined by his surgical status, for the injury from trauma or burns can be treated specifically and urgency is of importance. If the radiation injury is such that the patient can survive, there will be a latent period which eliminates the need for urgency. Those patients who have been exposed to a fatal dose of radiation should not be given the same priority for surgical care which might otherwise exist.

If under these circumstances one uses the accepted classification of injured and burned patients described in Emergency War Surgery,³ it is possible to arrive at a suitable classification of patients.

For convenience this classification can be summarized as follows:

Category 1. Casualties with minimal wounds or burns who after simple first-aid can be directed to self-care or to the care of Emergency Welfare Services.

Category 2. Casualties needing simple initial care, further care being deferred until a later date; delayed treatment will result in little added risk.

Category 3. Casualties for whom early life-saving treatment assures reasonable chances of survival.

Category 4. Casualties so critically injured or burned that their chances of survival are questionable even under the best circumstances; this group is often termed the expectant group.

Using these four categories of Surgical Injury along with the three categories of Radiation Injury, the chart in Fig. 1 can be obtained.

As can be seen, all patients in categories C1, C2, C3, C4 and those in B4 and A4 will be treated on an expectant basis in a mass casualty situation. Patients in categories A3 and B3 will be given urgent priority, while those in categories A2, B2 and B1 will be given normal priority with deferred treatment. Patients in category A1 will receive first-aid and self-care with discharge for observation of potential radiation damage.

| | | RADIATION | | |
|--------------------------------------|---|-----------|---|---|
| | | A | B | C |
| S U R G I C A L | 1 | | | |
| | 2 | | | |
| | 3 | | | |
| | 4 | | | |

Fig. 1.—Diagram for classification of combined injury. Patients in the shaded areas should be treated on an expectant basis.

In attempting to assess the additional hazard resulting from multiple injuries it is difficult to prove any synergistic action. It appears more likely that the effects of two forms of injury are additive. When the injury is slight, it would have little effect on the outcome from injury of another type. This would suggest that radiation injury falling into category A would have little effect on the outcome of surgical patients in categories 2 and 3. Similarly, patients in category B who have also suffered minor surgical injury would not necessarily have reduced chances of recovery. However, patients in category B3 may very well be in a position where the

combined effects would disproportionately decrease the chances of recovery.

Obviously patients with open wounds or severe burns with their additional risk of infection and hemorrhage will be in greater danger during the period of hemopoietic depression. Patients who have had moderately heavy irradiation (over 300 rads) will probably show some delay in healing which in turn will complicate the surgical injuries. Nevertheless, because of inability to differentiate between higher and lower dosages received by patients in category B, it would seem that these patients should be considered as potentially curable and should be considered as urgent cases.

SUMMARY

An attempt has been made to provide a classification of radiation injury on a clinical basis which will be useful in determining priorities for evacuation and treatment in the event of a nuclear disaster. The treatment of the acute radiation syndrome has been discussed briefly and the concurrent injury from trauma or burns and their implications have also been considered.

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